ON THE EFFECTIVENESS OF THE LOCALLY FORMULATED CUTTING FLUID

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ABSTRACT:

A Locally made cutting fluid emulsion of 15% concentration was formulated. Machinability tests were conducted on medium carbon steel using a single point high-speed steel (HSS) cutting tools to determine the effectiveness of the formulated cutting fluid. The cutting speeds of 24, 27, 30, 33, and 36m/min were used. The flanks wear land and nose wear of the tool were measured after each machining interval using mitutoyo toolmakers microscope with a magnification of 30. It was found that the tool wear characteristics and tool life, using the locally formulated cutting fluid were in close agreement with the previous works. The maximum deviation of 4.3% on flank wear and 8.9% on nose wear were recorded.

nearly the same as the wears with conventional cutting fluid?

Key words:- Locally, formulated, cutting fluid, machining.

INTRODUCTION

Machining is usually employed to produce shapes with high dimensional tolerances, good surface finish and often with complex geometry. The importance of machining cannot be over-emphasized in engineering products. More than 80% of all manufactured parts must have undergone one machining process or the other before they are completed (Dieter 1988). Excessive friction and heat are two major effects accompanying machining operations. Cutting fluids can improve the efficiency of machining operations by the following means: cooling the cutting tool and the work piece; lubricating the cutting and non-cutting surfaces on the tool; inhibiting seizure between the chip and tool, flushing the chips from the work area.

When cutting fluid is used, it can bring about improved surface finish, better control for work piece accuracy, lower tool cutting force, faster cutting speed or improved tool life. Rust prevention on the newly machined surface is another important function of the cutting fluid (Baker, 1969). For most machining operations, cutting fluids in large volume at low pressures are supplied to the cutting points (Lissaman, and Martin, 1993). Nozzle flow rates of between 2.273×10^{-4} to 7.577×10^{-4} m^3/s are used depending on the job (Carmichael, 1950; Baker, 1969). The conventional way of applying the fluid onto the work piece is from the top, which also helps in reducing fumes.

Recently, some attention is being given to forcing the cutting fluid upwards between the tool and the work for turning operations. This method increase tool life more than feeding from above as reported by Baker (1969) and Chapman. (1978). Whatever the system employed, a plentiful supply to the cutting point is essential to prevent overheating and fuming. The heat generated in any operation is imparted to the tool, the chips and the work piece in various proportions according to the conditions and class of action of cutting fluids register little effect on the cutting speed (more than 60mm/min) chemical action of cutting fluids register little effect on the cutting efficiency, being only marginally better than dry cutting (Lissaman and Martin, 1983). This means that for high-speed machining it is only the cooling action, which is operative, compared to the lubricating action. Similar to the lubricating action, effectiveness of cooling also depends on the physical access of the fluids to the cutting zone (Lissaman and Martin, 1983). However, experimental evidence suggests that cutting temperature is reduced by the cutting fluid action.

Among all the fluid, water-base fluid offer efficient cooling owing to their high specific heat and thermal conductivity. Hence, water base fluids can transfer the heat at a rate two to three times faster than oil. However, a point to be noted here is that cooling efficiency of the cutting fluid is not solely decided by its thermal properties (Holmes, 1971). Others factor such as wetting action (fluid with low surface tension) and vapour formation influence the cooling action of the cutting fluids.

Various commercial formulation of cutting fluids exist (Holmes, 1971): Due to the economic downtime in Nigeria, these cutting fluids including the popular general-purpose synthetic cutting fluids are no longer readily available. In order to alleviate the scarcity and expensive cutting fluid, recently, Muktar and Ibhadode (1999), formulated cutting fluid with readily available local materials.

However, the objective of this present study is to determine the effectiveness of this locally formulated cutting fluid through the following methods.

- By adopting the same procedure of formulation
- By comparing the result of this work with previous results of the cutting fluids on the tool wear characteristics

EXPERIMRENTAL PROCEDURE

By adopting the same procedure of formulation of the locally produced

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cutting fluid by Muktar and Ibhadode (1999), the following soluble oil formulation was derived as shown in Table 1 below:

Table 1: The percentage by weight of the concentrated constituents

Materials	%Weight
Emulsifying wax	9
Soap	9
Potassium dichromate	0.075
2- Naphtol	0.075
Sulpur	0.05

The table shows the percentage by weight of the concentrate constituents. The above solids were dissolved in the engine oil SAE40 by heating to above 60°C. The commercial soluble oil – Agip Ulex100 as sample I and the formulated cutting fluid as Sample I. Both fluids were used at 15% concentrated in water.

For a particular cutting, straight turning was carried out using a POHDI PH 3690 HSS10 (10 x 10mm^2) tool on a Harrison 170/1000 centre lathe. The tool was ground to the angles shown in Figure 1 (a), namely 8° end lathe, relief 16° and cutting edge 74°, lip angles and all other angles including the rake were zero. Figure 1 (b,c) show the graphical representation of the flank and nose wear lands respectively. With the sample I cutting fluid in the sump of the lathe, turning was carried out at a speed of 24mm/min. The machining was done at time intervals. For each machining time, the profiles of the tool cutting edge before and after machining, were taken using a Mitutoyo Tool Maker's microscope , with magnification of 30. The procedure was repeated for four other cutting speeds, namely 27,30,33 and 36mm/min. These peripheral cutting speeds were obtained at a constant spindle speed of 305rpm by variation of work piece diameter.

The fluid in the sump was replaced by sample II cutting fluid after it had been flushed and the above procedure as repeated for the five different speeds. The cutting fluid was flowing as 1000cm³ in every minutes. The work piece material was a medium carbon steel with composition of carbon in range of 0.25 to 0.40% and of hardness BHN. The depth of cut and feed were kept constant for all tests at 0.2mm and 0.15mm/rev. respectively.

RESULTS AND DISCUSSION

TOOL PROFILES

Figure 2 shows typical worn tool profiles on the flank, as viewed from the side to the tool at cutting speed of 33mm/min of both sample of cutting fluids while Figure 3 shows typical worn tool profiles on the nose as viewed from the top, for cutting speed of 33mm/min for the two samples of cutting fluids. The figures indicates that wear occurs very rapidly on the tool flank and nose within the first minute of machining for both cutting fluid samples. This observation was also reported by Muktar and

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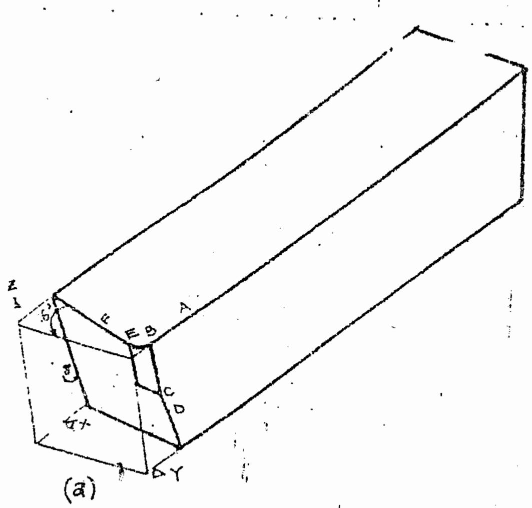

FIG. 1a THE VIEW OF THE ANGLES OF THE EDGE OF THE TOOL

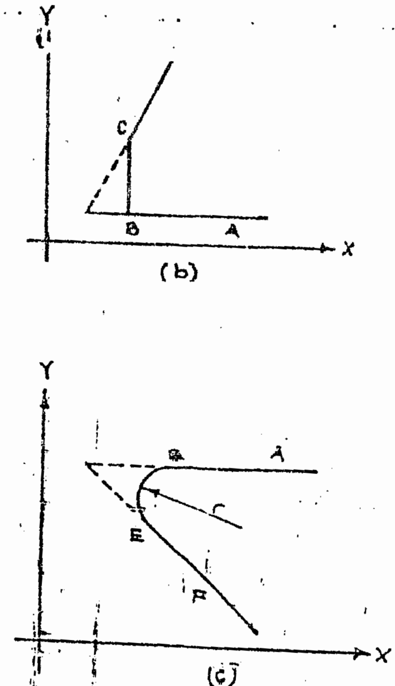

FIG 1b,c GRAPHICAL REPRESENTATION OF THE FLANK AND NOSE WEAR LANDS

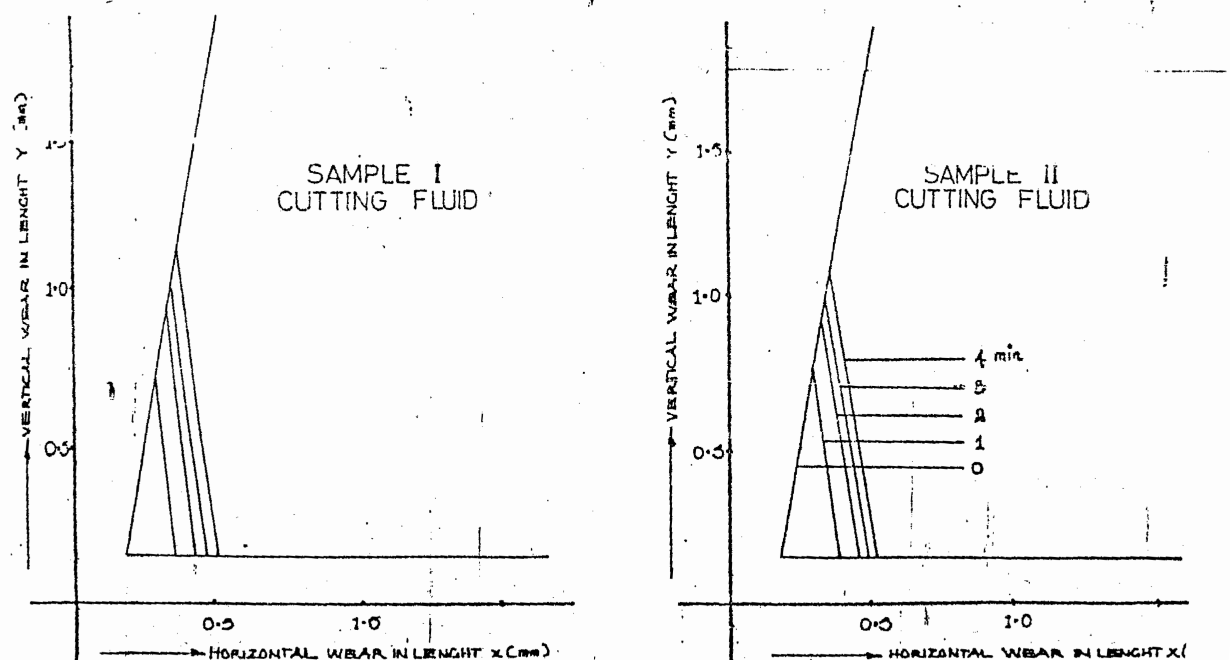

FIG. 2 SIDE VIEW PROFILES OF THE CUTTING EDGE FOR VARIOUS MACHINING TIMES AT CUTTING SPEED OF 83 m/mm FOR BOTH SAMPLE OF CUTTING FLUIDS.

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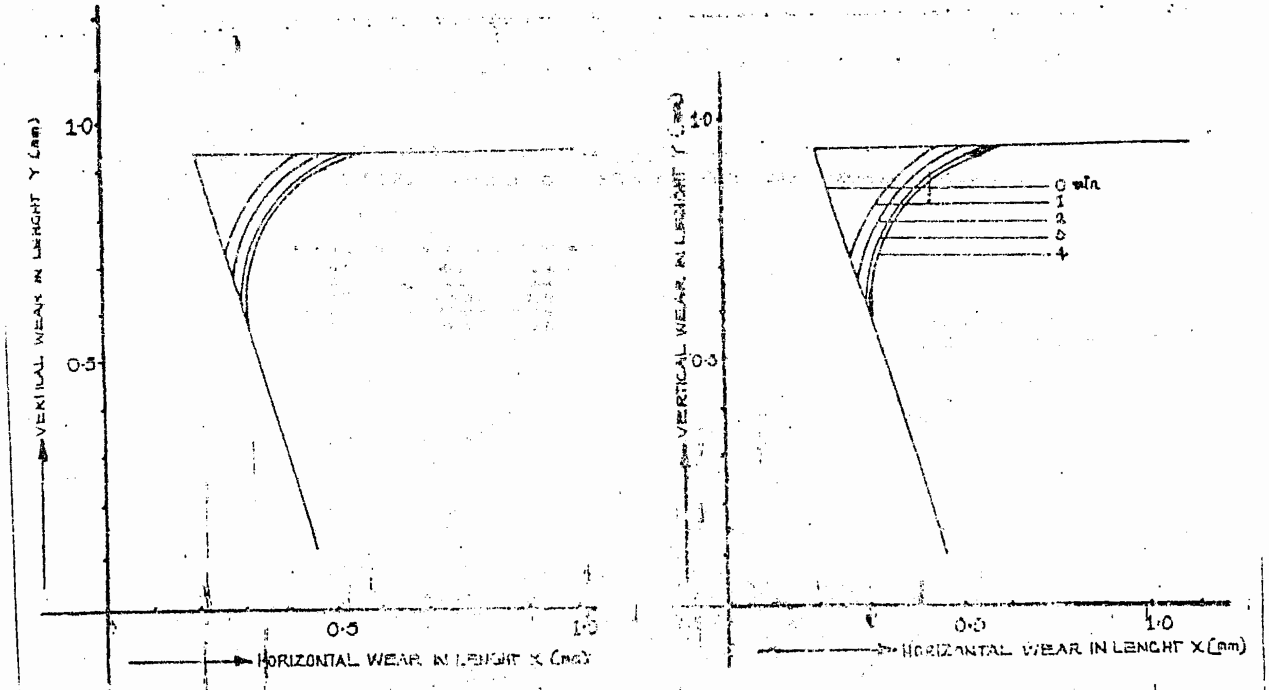

FIG. 3 TOP VIEW PROFILES OF THE CUTTING EDGE FOR VARIOUS MACHINING TIMES AT CUTTING SPEED OF 35 m/min FOR BOTH SAMPLES OF CUTTING FLUIDS.

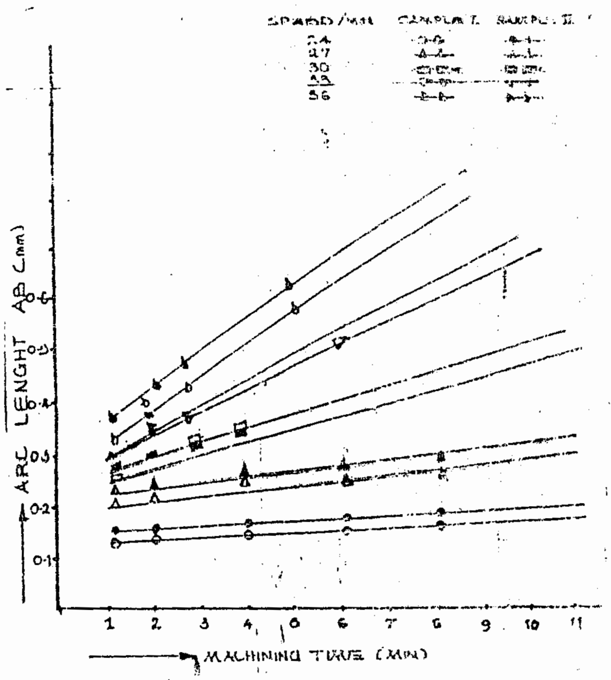

FIG. 4 VARIATION OF ARC LENGHT AB WITH MACHING TIME FOR BOTH SAMPLE OF CUTTING FLUIDS AT VARIOUS SPEED

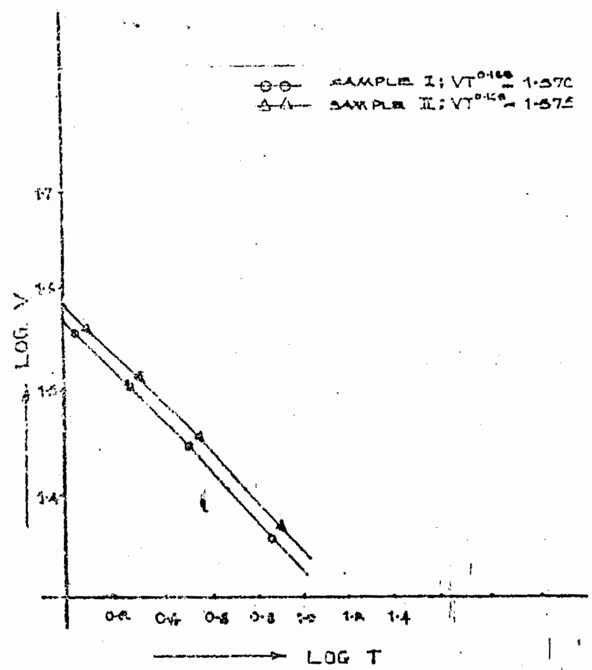

FIG. 5 LOG V AGAINST LOG T

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Ibhadode (1999). Thereafter, further increase in wear takes place less rapidly. This is expected because the first stage of a typical wear curve is the initial breakdown of the cutting edge Dieter (1988). For example after one minute of machining with sample 1 cutting fluid, the flank wear lands were 0.65 and 0.76mm for cutting speeds of 24 and 30mm/min respectively. Whereas after 6 minutes of machining the respective wearlands were 0.210 and 0.230mm/min. For cutting fluid sampleII, after four minutes of machining the flank wear land were 0.260, 0.340 and 0.385 for cutting speeds of 27, 30 and 33mm/min respectively. The explanation for this may be due to the fact that for freshly continuously as the distance behind the cutting edge increases within the tool cutting point.

Due to the smaller amount of materials within the tool tip the flank at the top tip wears very rapidly. However, the rate of wear of flank decreases as more materials of the tool are exposed to the cutting action.

It was also observed that as machining begins there was rounding of the tool nose, such phenomenon was reported by Wilson and Harvey (1959) and Boothroyd (1975). As machining time increases the nose radius also increases for both samples of cutting fluids. As cutting speed increases, the flank and nose wear increase for both sample 1 and 11 of cutting fluid. For example at four minutes machining time, the flank wearlands when machining with sample 1 and 11 cutting fluids were 0.85 and 0.87mm respectively for cutting speed of 27mm/min. whereas for the same machining time the respective wearlands at cutting speed of 33mm/min. were 1.42 and 1.48mm, this is due to the fact that as the speed increases there will be more rubbing action of the tool against the work piece for a given time due to the rapid breakdown of the tool tip.

PLANK AND NOSE WEAR

Figure 4 shows the plots of flank wearland and nose wear are against machining time at various cutting speeds. The figure shows that at all speed, the flank wearland and nose wear arcs obtained from the formulated sample II cutting fluid are marginally greater than those for the commercial one as labeled sample I. Table 2 shows maximum deviations of flank wearland of sample II cutting fluid over sample I, as obtained by Muktar and Ibhadode (1999) and the present work results.

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Table 2: The Deviation of the Flank wearland and Nose wear results

Speed mm/min	A Percentage of flank Wearland deviation	B Percentage of flank Wearland deviation	Percentage of flank Wearland deviation
24	1.8	1.5	2.7
27	2.8	2.6	4.1
30	3.2	2.9	5.6
33	4.2	4.3	8.9
36	3.2	3.0	2.0

A= Muktar and Ibhadode (1999)
B= Present work

For example when machining with sample I cutting fluid at a cutting speed of 27mm/min for machining times 1,2,4 minutes, the flank wear lands were 0.65, 0.71 and 0.85mm respectively. Whereas when sample II cutting fluid was used the flank waerlands were 0.66, 0.73 and 0.87mm. Similarly, when using sample II cutting fluid at cutting speed of 36mm/min for machining time of 1, 1.5 and 2 minutes the flank wearland were 1.06, 1.17 and 1.28mm respectively. While flank wearland of 1.04 and 1.24mm was obtained using sample I cutting fluid.

The reason for the marginal higher performance of sample I cutting fluid over sample II may be due to the fact that the sample might have had more sulphur and other extreme-pressure additives, such as chlorine as reported by Muktar and Ibhadode (1999).

The nose wear displaced the same character as the flank wear in that the wear using sample II cutting fluid at all cutting speeds was more than that using sample cutting fluid for example by machining with sample I cutting fluid at cutting speed of 24mm/min for 1, 2, and 4 minutes the wearlands were 0.146, 0.156 and 0.175mm respectively, whereas the wearlands by using sample II cutting fluid were 0.156, 0.162 and 0.181mm.

Similarly at 30mm/min cutting speed, the nose wearlands for 2, 4, and 6 minutes were 0.262, 0.340 and 0.423 using sample II cutting fluid respectively. Whereas nose wearland of 0.243, o.315 and 0.380mm were obtained using sample I cutting fluid. The same argument given under flank wears for having worn profile using sample I at all the cutting speeds is also applied in this case. It is observed from the figure that the points are a little bit scattered, which shows the irregularities in the machining. These irregularities may be as a result of the following:-

(i) Nature of engagement of tool with workpiece
(ii) Rigidity of the workpiece
(iii) Accuracy of tool holding devise and feeding mechanism and

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(iv) Rigidity of the machine tool used.

TOOL LIFE:

In terms of machining cost, tool life is usually one of the most important criteria of the machinability. It is not easy to define tool life without ambiguity (Dieter, 1988). Mostly at the point, which the tool no longer makes satisfactory impacts economically, determines tool life.

However, there are more specific criteria of tool life used such as complete failure. Figure 5 shows the logarithm of the tool cutting velocity against the logarithm of the time for the cutting fluid which depends on wear rates, and it was observed that as the speed increase the tool life decreases. The Taylor tool life equation as reported by Wilson and Harvey (1959), is given by:-

$$VT^n = Ct \ldots\ldots(1)$$

Where V is the cutting velocity (mm/min). T is the tool life in minutes, n is an exponent whose value to the same extent with the other machine variable and the workpiece material variables and Ct is, the constant whose value depends on the other machine variables and the work. material variable. The above equation is derived for a tool life of 1.1mm flank wearland.

Evaluating this equation for their cutting fluid samples, Muktar and Ibhadode (1999) found n to be 0.166, whereas n found in this work was 0.165. The results are very close. Typical values of n when machining steel with high speed steel tool are 0.1, Dieter (1988). (0.125) Radford and Richardson (1978), and 0.14/0.15, Wilson and Harvey (1959). The tool life exponent n is an indication of sensitivity of vibration of the machining operation according to Wilson and Harvey (1959).

CONCLUSIONS

The tool wears characteristics of the locally formulated fluid compare well with those of the previous work, although with marginally higher wear characteristics when compared with that of the commercial.

Since the results of the tool wear characteristics and tool life are in close agreement, therefore the formulated cutting fluid can be used for machining.

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